INDOOR AIR QUALITY ASSESSMENT

Country School
Alphabet Lane
Weston, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Wendy Diotalevi, Director of the Weston Health Department, an indoor air quality assessment was done at the Country School, Alphabet Lane, Weston, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). Indoor air quality concerns related to on-going construction/renovation activities prompted the assessment.

On March 4, 2003, a visit was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an assessment. Mr. Holmes was accompanied by Ms. Diotalevi. The building consists of two wings. The original building was constructed during the 1960s as a single story red brick structure. The original wing was recently renovated and a new wing was under construction at the time of the assessment (see Picture 1). Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This elementary school has a student population of approximately 180 and a staff of approximately 65. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

Carbon dioxide levels were within the comfort guidelines set by the BEHA indicating adequate air exchange in the majority of areas surveyed. It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in four of nineteen areas tested.

Fresh air in classrooms is supplied by a unit ventilator (univent) system or rooftop air handling units (AHUs). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating/cooling coil, and is then provided to classrooms by motorized fans through fresh air diffusers located at the top of the unit (see Figure 1). AHUs draw air from outdoors through a fresh air intake and distribute it to occupied areas via ceiling-mounted diffusers connected to ductwork. Univents and AHUs were functioning in all areas examined. Univents and some air diffusers were found obstructed by various items in several classrooms (see Tables/Pictures 2-4). In order for univents to function as designed, the fresh air diffuser and return vents must be clear of obstacles.

Exhaust ventilation in classrooms is provided by ceiling mounted grilles connected to rooftop motors via ductwork. Exhaust vents were operating in all classrooms surveyed.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The ventilation system should be balanced following completion of the renovation/construction project. The last date of balancing of these systems reportedly occurred in 1996. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix I.

Temperature measurements ranged from 68^{o} F to 78^{o} F, which were close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Heat complaints were reported on the second floor near the school nurse's suite. The school nurses' suite is located directly across from a series of heating vents in the upper wall of the lobby (see Picture 5). These vents appeared incomplete due to the lack of louvered grates on the terminus of the ductwork. Without louvered vents to direct air downward (to warm incoming occupants) the ducts force hot air straight across the lobby toward the second floor nurses' suite.

Heat complaints were also expressed in room C-112. In an effort to reduce heat, the supply vent in C-112 was blocked with masking tape and cardboard (see Picture 6). This alteration of the system, however, can throw the system off-balance and create uneven temperature conditions in areas adjacent to the blocked diffuser.

The relative humidity in the building ranged from 10 to 14 percent, which was below the BEHA recommended comfort range in all areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several rooms contained a number of plants, some of which were located near univents. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plant soil and drip pans can also provide a source of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents to prevent the aerosolization of mold, dirt and pollen.

Water damaged ceiling tiles were observed in room 202 (see Pictures 7). Occupants reported an active roof leak in this area. Water-damaged ceiling tiles and porous building materials can provide a source of microbial growth and should be replaced after a water leak is discovered.

Renovation/construction Concerns

Renovation activities can produce a number of pollutants, including dirt, dust, particulates, and combustion products such as carbon monoxide (from construction vehicles). Particles generated from construction activities can settle on horizontal surfaces in classrooms. Dusts can be irritating to the eyes, nose and respiratory tract. As discussed, during the BEHA assessment an addition to the building was being constructed, however, no construction/renovation work was being conducted within the occupied portion of the Country School.

A number of construction vehicles and piles of dirt/construction debris were noted around the perimeter of the building. The opening of windows allows for unfiltered air to enter the in environment carrying with it airborne dirt, dust and particulates. As mentioned previously, BEHA recommends the use of existing mechanical ventilation components in a building while occupied, however univents can mechanically draw in particulates and products of combustion such as carbon monoxide. These materials can be irritating to the eyes, nose and respiratory tract. Due to the dynamic nature of construction/renovation activities, building occupants should be aware of activities being conducted outside of their classrooms' and determine the appropriateness of opening windows and/or temporarily limiting fresh air intake.

Other Concerns

Other conditions were noted during the assessment that can affect indoor air quality. Many rooms contained dry erase boards. Dry erase board particulates can be easily aerosolized and serve as eye and respiratory irritants. In addition, materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

Sewer gas odors were reported in the second floor girl's restroom. Restrooms are equipped with floor drains. Drains are designed with traps in order to prevent sewer odors/gases from penetrating into occupied spaces. When water enters a drain, the trap fills and forms a watertight seal. Without periodic input of water (e.g. every other day), traps can dry and compromise the integrity of the watertight seal. If traps dry out, sewer odors/gases can travel up the drain into occupied areas.

Conclusions/Recommendations

General Indoor Air Quality

In view of the findings at the time of the inspection, a number of recommendations are made to improve indoor air quality. Specific advice related to renovation activites is also provided. Recommendations include:

1. Continue working with HVAC contractor to troubleshoot problems and develop a preventive maintenance plan for all HVAC equipment.
2. Continue working with an HVAC firm to balance the mechanical ventilation system. Consider having the ventilation system balanced by an HVAC engineer every five years (SMACNA, 1994).
3. Remove all obstructions from univent air diffusers and return vents to facilitate airflow.
4. Faculty and staff are encouraged to report any complaints concerning temperature control/preventive maintenance issues to the facilities department via the main office.
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
6. Relocate plants that are in close proximity to univent fresh air diffusers. Remove plants in direct contact with carpeting.
7. Ensure water is poured into floor drains regularly to maintain the integrity of the traps.

8. In order to provide self assessment and maintain a good indoor air quality environment on your building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
9. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Construction/Renovation Activities

The following recommendations should be implemented in order to reduce the migration of renovation-generated pollutants into occupied areas and the potential impact on indoor air quality. We suggest that these steps be taken on any renovation project within a public building.

1. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
2. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
3. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
4. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals

during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).

5. Consult MSDS' for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.

6. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).

7. Seal utility holes, spaces in roof decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in ceiling temporarily to prevent renovation pollutant migration.

8. Where applicable, seal construction barriers with polyethylene plastic and duct tape to create a secondary barrier to prevent migration of renovation generated pollutants into occupied areas.

9. Inspect classrooms for cleanliness and construction barriers for integrity daily prior to the opening of school. Consideration should also be considered to inspect

construction barriers at the end of the school day prior to construction work. In addition, encourage staff to report any breaches in construction barriers immediately.

10. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.

11. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

12. To prevent renovation generated pollutants from entering the building, occupants in classrooms in close proximity to construction areas, should be aware of outside construction activities and keep windows closed during periods which generate heavy dust and/or odors. As previously noted, if air intakes are in close proximity to vehicles/products of combustion occupants should determine the appropriateness of opening windows and/or temporarily limiting fresh air intake.

13. Consider changing univent filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

14. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

15. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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Picture 1

Country Elementary School With New Addition in Foreground

Picture 2

Classroom Univent Surrounded By Furniture Obstructing Airflow

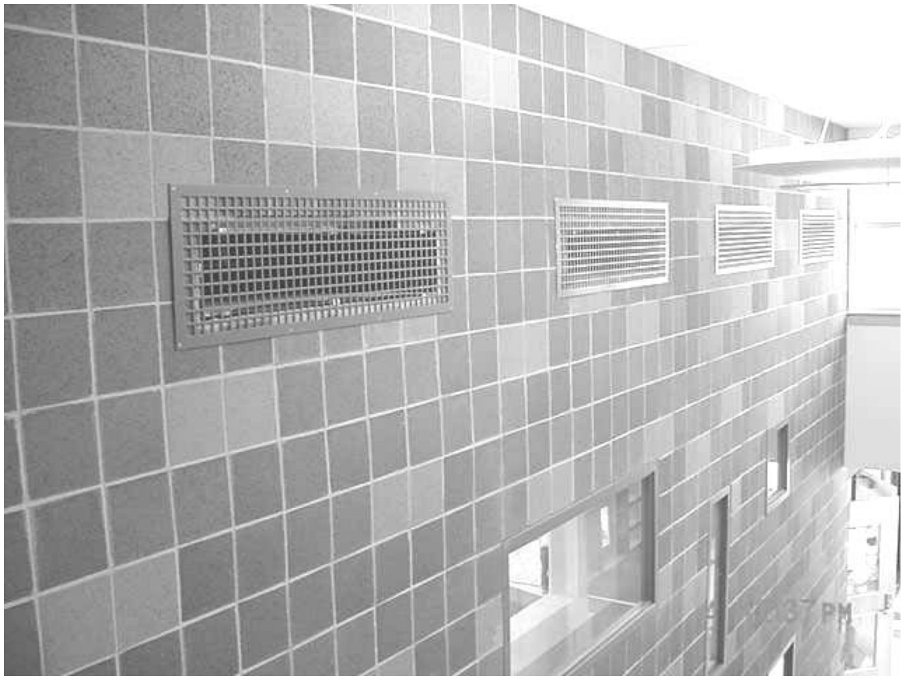
Picture 3

Items Obstructing Univent Return Vent

Picture 4

Ceiling-Mounted Air Diffuser Obstructed by Boxes Stored on Cabinet

Picture 5



Lobby Heating Vents across from Nurse's Suite, Note Lack of Louvered Grates for Directional Airflow

Picture 6

Blocked Vent in Room C-112

Picture 7

Water Damaged Ceiling Tiles in Room 202

TABLE 1

Indoor Air Test Results – Weston Country Elementary School, Weston, MA **March 4, 2003**

Location	Carbon Dioxide (*ppm)	TVOCs (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Outside (Background)	388	0.0-0.2	41	13					Cold, clear skies, westerly wind 5-10 mph
Main Hallway									25 students gone for 5 min door and window open
Gym Hallway									Exposed fibers
Room 109	490		66	15	1	Y	Y	Y	Debris 3 CT
Room 202	530	0.0	70	13	0	Y	Y	Y	CT saturated/wet Current roof leak, CT 5.2%
School Nurse	578		78	10	2	Y	Y	Y	Heat complaints
2nd Floor Hallway									Heat issues from blowers No louvers
Room 17	844		74	11	11	Y	Y	Y	Door open Items on front UV
Room 20	796		73	12	4	Y	Y	Y	14 plants Plants near UV
2nd Floor Girl's Restroom									Odors backed up vent
Room 14	692		71	10	20	Y	Y	Y	Window open

*** ppm = parts per million parts of air**
UV = Univent
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	TVOCs (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Room 12	730		71	11	22	Y	Y	Y	Door open
Room B 121	726		70	12	16	Y	Y	Y	Items in front of UV
Room B 126	693		70	12	20	Y	Y	Y	
Room B 124					0	Y	Y	Y	Plants obstruction of furniture built around UV, humidifier 15-20 occupants gone 10 min.
Music Room	561		70	10	1	Y	Y	Y	25 occupants gone 45 min.
Room 10	788		68	12	24	Y	Y	Y	Door open Plants
Room 7	718		70	13	25	Y	Y	Y	Door open
Room 9	718		70	12	19	Y	Y	Y	Items on/front of UV
Room 8	726		70	13	22	Y	Y	Y	UV blocked air flow by furniture
Room C 109	425		58	13	1	Y	Y	Y	Window open
Room C 112	459		60	14	0	N	Y	Y	Heat issues

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Room C 108	510		67	13	1	N	Y	Y	

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